Safety Guide 100

DESIGN GUIDE FOR PACKAGING AND OFFSITE TRANSPORTATION OF NUCLEAR COMPONENTS, SPECIAL ASSEMBLIES, AND RADIOACTIVE MATERIALS ASSOCIATED WITH THE NUCLEAR EXPLOSIVES AND WEAPONS SAFETY PROGRAM

CHAPTER 8.0

ACCEPTANCE TESTING AND MAINTENANCE

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ACRONYMS

ALARA	As Low As Reasonably Achievable
ASME	American Society of Mechanical Engineers
ASNT	American Society of Nondestructive Testing
DOE	Department of Energy
DOT	Department of Transportation
HAC	Hypothetical Accident Conditions
M&TE	Materials and Testing Equipment
MNOP	Maximum Normal Operating Pressure
MSLD	Mass Spectrometer Leak Detector
NCT	Normal Conditions of Transport
OTC	Offsite Transportation Certificate
QA	Quality Assurance
QAP	Quality Assurance Procedure
QC	Quality Control
SARP	Safety Analysis Report for Packaging

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DEFINITIONS

Containment System	Components of the packaging intended to retain the radioactive material during transport.
Exclusive Use	The sole use of a conveyance by a single consignor and for which all initial, intermediate, and final loading and unloading are carried out in accordance with direction of the consignor or consignee.
Hydrogenous	Material containing the element hydrogen.
Moderator	A material used to reduce the kinetic energy of neutrons by scattering collisions without appreciable neutron capture.
Package	The packaging, together with its contents.
Packaging	The assembly of components necessary to ensure compliance with the packaging requirements.
Quality Assurance	All those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily and safely in service.
Safety Analysis Report for Packaging	A document that provides a comprehensive technical evaluation of the design, testing, operational procedures, maintenance procedures, and quality assurance program to demonstrate compliance with Nuclear Regulatory Commission and Department of Transportation safety standards, or equivalent standards established by the Department of Energy for approving packagings and issuing certificates of compliance.
Streaming	Unrestricted movement of photons and neutrons from a radioactive source.
Specific Activity	The radioactivity of the radionuclide per unit mass.

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8.0 ACCEPTANCE TESTING AND MAINTENANCE

8.1 INTRODUCTION

8.1.1 Objective and Scope

In this chapter, the kinds of acceptance and/or verification tests and inspections required for the packaging and its components (both at the vendor's and the owner/user's) are described; appropriate acceptance criteria for those tests are defined; and the constituents of an acceptable maintenance program are described. The goal of this chapter is to give the reader a basic understanding of the regulations concerning acceptance testing and maintenance, guidelines for establishing an acceptance testing and maintenance program, and how to document that program in the Safety Analysis Report for Packaging (SARP). This chapter does not address design verification tests; they are included in Chap. 2, Structural Analysis. The requirements for acceptance testing and maintenance cover all packaging components, the assembled packaging, and the complete package.

8.1.2 Developing an Acceptance and Maintenance Program

The first step in developing a successful acceptance and maintenance program is to organize teams responsible for developing the acceptance and maintenance program. Each team should be composed of diverse individuals. For acceptance testing, the team should consist of representatives from Packaging Design and Safety, Procurement, Quality, and Operations. Similarly, for maintenance the team should consist of representatives from Packaging Design and Safety, Quality, and Operations.

Once the program teams have been developed, each team must be trained for the package under consideration. Package-specific training ensures that each team member fully understands all processes.

Development of an acceptance testing and maintenance program is highly dependent upon the packaging design and the quality categories of the packaging components (see Chap. 9). Test requirements are specified in the regulations and Department of Energy (DOE) Orders; however, the exact type of test, the test procedure, and acceptance criteria vary depending on the specific components used in the packaging and their individual quality category.

The ability to test/inspect and maintain a package impacts package designs. Therefore, understanding the interdependency that exists between individual design efforts on the overall package design is important. The input needed from other design disciplines to develop a successful acceptance/maintenance program is shown in Fig. 8.1.

The driving force behind developing a maintenance and acceptance testing program is the need to comply with the regulations governing the transportation radioactive materials. Therefore, it is the responsibility of each team member to have an adequate understanding of the regulations.

8.2 REGULATORY REQUIREMENTS

8.2.1 Regulations

The regulatory requirements for acceptance testing and maintenance of radioactive and hazardous material transport packaging are found in 10 CFR 71, *Packaging and Transportation of Radioactive*

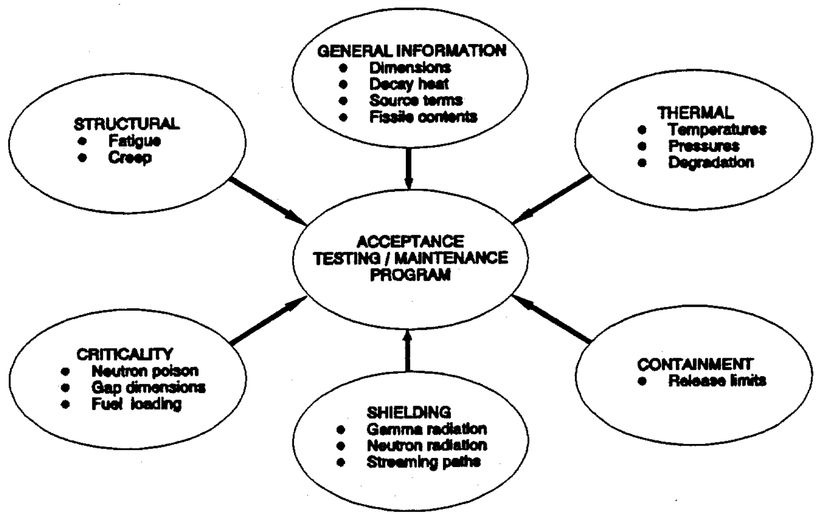

Fig. 8.1 Relationship of acceptance/maintenance programs to other disciplines.

Materials,[1] with inclusion by reference to Department of Transportation (DOT) requirements.[2] Additional programmatic requirements for DOE-certified packaging can be found in DOE Orders 1540.2,[3] 5480.3,[4] and 5700.6C.[5] Guidance for preparation of Chap. 8 of the SARP is given in Regulatory Guide 7.9[6] *Standard Format and Content of Part 71 Applications for Approval of Packaging of Type B, Large Quantity, and Fissile Radioactive Material.* These regulations, requirements, and guidance documents are discussed in more detail in the following section.

8.2.2 General Packaging Requirements

Subpart G of 10 CFR 71,[1] *Operating Controls and Procedures,* dictates certain activities that must occur prior to the first use of Type B packaging. Specifically, the owner/user must determine that the packaging is free from any physical defect that would reduce the effectiveness of the packaging. In addition, if the maximum normal operating pressure (MNOP) will exceed 5 psig, the containment system must be tested at an internal pressure at least 50% higher than the MNOP. Most importantly, the owner/user must determine that the packaging has been fabricated in accordance with the approved design prior to marking the packaging. This requirement drives the need for an acceptance testing and maintenance program.

The guidance in Regulatory Guide 7.9[6] addresses the tests to be performed prior to the first use of the packaging: visual inspection for physical defects, structural and pressure tests, leak tests, and individual component tests. Each component whose failure would impair the effectiveness of the packaging should be tested under the most severe conditions the component was designed for. These components include but are not limited to valves, rupture disks, fluid transport devices, and gaskets. All components must be procured under an approved quality assurance program.

If any of the packaging components are required for shielding integrity or thermal protection, then tests must be performed to assure that the shielding requirements for the packaging are met and that the thermal protection maintains the temperature acceptably in accordance with thermal analyses or tests conducted for normal conditions of transport (NCT).

Acceptance criteria for each test must be specified, and the packaging shall not be used until all acceptance criteria are met. The acceptance testing and maintenance procedure must describe actions to be taken if acceptance criteria are not met. Tests and inspection performed and their acceptance criteria shall be determined on the basis of the quality category of the component or of the packaging as a whole (i.e., the severity of the effect on packaging integrity should a component fail).

In addition to providing for acceptance testing prior to first use, a maintenance program is required to assure the integrity of the packaging for subsequent use. Maintenance tests and inspections should be conducted at least annually and prior to each use. The containment vessel should be leak tested at least annually. Each packaging is postload leak tested prior to shipment. O-rings, seals, and gaskets are changed on a periodic schedule and upon detection of any defect. Other damage due to normal wear and tear should be repaired upon detection. Other tests, inspections, repairs, or replacement activities may be required depending on the use of packaging components or subsystems whose failure could impair packaging performance.

The maintenance program must describe the action to be taken when packaging defects are detected and the acceptance criteria for returning the package to service. All components must be refurbished or replaced so that the packaging will meet first-use test requirements.

8.2.3 Quality Assurance

Quality Assurance (QA) activities for all related packaging activities, including acceptance testing and maintenance, must conform with the applicable requirements of DOE Order 5700.6C,[5] 10 CFR 71,[1] Subpart H, or other codes or standards.

The selective application of quality assurance requirements begins with adherence to approved procedures for the control of all acceptance testing and maintenance activities during the design and use of packaging. These procedures typically include control of testing, control of measuring and test equipment (M&TE), control of servicing and maintenance, and control of documents and records.

A nonconformance and corrective action system should be in place to handle deviations or nonconformances identified during the acceptance testing and maintenance phases. Deviations from requirements and procedural controls should be documented and appropriate personnel identified to adequately evaluate and disposition each deviation. The owner of the packaging should be included in this procedural system.

A recordkeeping system should be established, and records of the acceptance testing and maintenance activities must be maintained according to approved procedures.

To ensure the effectiveness of these controls, the appropriate organization should conduct periodic internal assessments of the adequacy of the acceptance testing and maintenance systems. Copies of nonconformance findings and corrective actions taken should be forwarded to the owner/user.

8.3 ACCEPTANCE TESTS

Acceptance and/or verification tests and inspections are performed to assure that packaging components meet their quality requirements and to verify the integrity of the packaging with respect to containment, shielding, and subcriticality. The tests and inspections also verify that the packaging meets the design requirements specified by the structural, thermal, containment, criticality, and shielding evaluations.

A number of inspections and tests, some at the vendor's facility and some on-site at the owner's, are required prior to acceptance and use of a packaging. Acceptance criteria for the specified tests must be defined and should relate directly to the quality level associated with each component.

Inspections and tests to be performed by the vendor at the vendor's site should be specified in the procurement specifications; many may also be witnessed by the owner's procurement and/or quality representatives. Tests that are generally required to be performed by the vendor at the vendor's site include a pressure test on the outer container, usually per a MIL specification, and a helium leak test, drop tests, dimensional inspections, a stack test on the inner components, and First Article Evaluations. For tests for which a standard test procedure has not been specified, the vendor must prepare a test procedure for site review and approval. Documentation of the results of all vendor-site tests and other required certifications should be with the packaging components when the components arrive at the owner's location. Components may be required to pass certain tests prior to being shipped to the owner.

Upon receipt of the package at the owner's site, the associated documentation and certifications should be audited. In addition, further acceptance tests, such as visual inspections, structural and pressure tests and individual component tests are required. Some typical acceptance requirements for Type B packages are shown in Table 8.1.

8.3.1 Visual Inspection

All components that make up the outer packaging and containment vessel of a package are visually inspected. This inspection verifies that all items are properly cleaned, free of nicks, gouges, and other damage that could affect package performance and that all components assembled in accordance with the design drawings. Each package item must be compared with the appropriate drawings to verify that the item is in the correct orientation or position and that it conforms in design and dimensions to the design drawings. According to standard practice, a package is visually inspected each time it is loaded.

8.3.1.1 Typical visual inspections performed and purpose

Visual inspections typically fall into two categories based on the level of detail required. For overpacks such as drums, visual inspections are designed to scrutinize the overall fit and finish, whereas the inspection of containment vessel components requires more rigorous examination.

Drum

When inspecting a drum, the components critical to the structural integrity of the package, such as the drum closure ring, are examined to ensure that bolt lugs are properly welded to the locking ring and the alignment of the lugs allows for easy insertion' and torquing of the locking ring bolt (see Fig. 8.2). The drum body is also visually inspected to see if scratches or gouges that compromise the thickness are present; if the gasket (when present) is in good condition, is flexible, and makes a good

Table 8.1. Typical acceptance requirements for Type B transportation packaging

Component	Visual inspection	Structural/ pressure tests	Leak tests	Other
Quality Category A				
Inner container	Gaging, marking, liquid penetrant, weld repair	Hydrotest	He	Material Certification and test reports
Containment	Gaging, packaging, marking	Shore A durometer, elongation	N/A	Material Certification
Quality Category B				
Drum	Gaging, marking, liquid penetrant, weld repair	Tensile, percent elongation, impact, yield point, chemistry	N/A	Material Certification
Lock bolt/ fasteners	Gaging, stamping	Tensile, percent elongation, impact, yield point, chemistry	N/A	Material Certification
Insulation inserts (fiberboard, plywood, nylon rope)	Gaging, stamping	N/A	N/A	Material Certification
Containment screw fasteners	Gaging, stamping	Tensile, percent elongation, impact, yield point, chemistry	N/A	Material Certification and Heat Treat Certification
Quality Category C				
Data plate and tag	Gaging	N/A	N/A	Material Certification
Security seal	Damage	N/A	N/A	Material Certification
Leak test plug	Damage	N/A	N/A	Material Certification

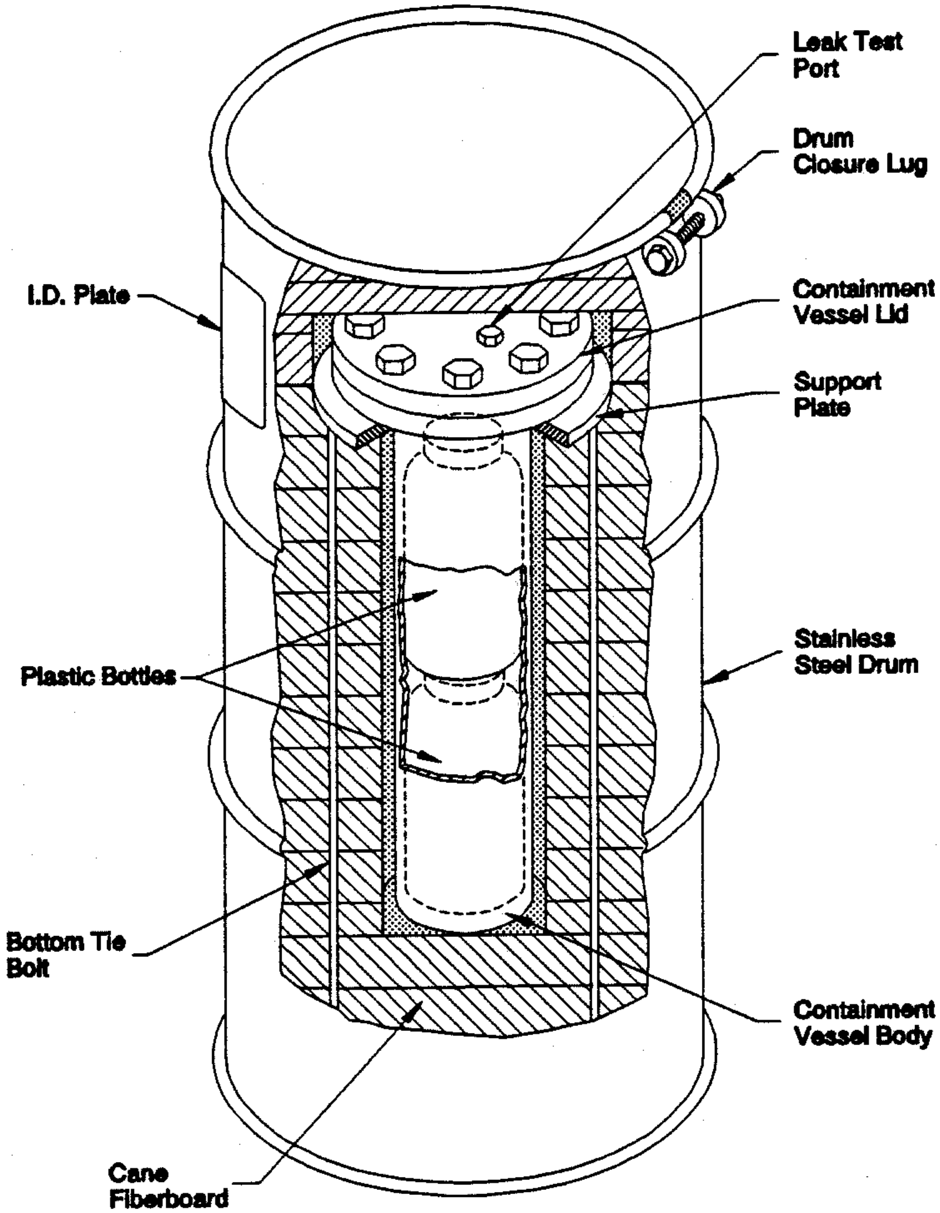

Fig. 8.2. Standard drum-type package.

seal; if the weld seam has not split; and if the vent holes are present and plugged. The drum bolts are important to the structural integrity of the package and they should be visually inspected to ensure they are the specified bolts and there is no damage that could reduce their effectiveness. To ensure adequate insulation thickness, a tape measure is used to check the radial clearance between the fiberboard and the drum and the axial clearance between the lid and the fiberboard. These inspections are carried out in accordance with approved site-specific inspection/product acceptance sheets. Drums that cannot be repaired are replaced.

At one site, the drum inspection is known as the kick-and-count inspection. Individual inspection procedure forms tailored to each packaging design are prepared. The forms also serve as the inspection record. Upon arrival on-site, the packagings undergo the kick-and-count inspection. The outer containers are checked for correct marking and labeling and gross physical defects, and the paperwork is checked to make sure that the latest and correct revision has been used. The insulation is checked at this point only on special request. Any nonconformances (defects or discrepancies) found are indicated on the form in red ink and are circled as well. If the outer container is rejected, the paperwork is forwarded to the Product Engineer and the component is tagged with an orange tag and sent to storage, where it is stored in an area segregated from the other containers, awaiting resolution by the Product Engineer. If an acceptable discrepancy is found, the paperwork is forwarded to the quality group for their records. Acceptable containers are sent to storage until they are needed. Approximately 50 containers can be checked in 1 to 2 days.

Containment vessel

The containment vessel and all associated components are procured in accordance with the design drawings and standard procurement specifications. Typically, the user organization personnel follow QA requirements for new packaging established by the design [e.g., American Society of Mechanical Engineers (ASME) Code requirementsl and described on the design drawing to verify that all the packaging inspections and tests have been performed and documented by the vendor and to establish the inspections and tests that will be performed by the user before use of the containment vessel. For each containment vessel, the vendor provides the following inspection and test reports which shall be traceable to the specific part: weld inspection, material test report or certification for all materials, welding procedure and qualification record, personnel qualification records, liquid penetrant inspections, dimensional inspection including recorded measurements and observations for all features designated as "Q" hydrostatic test, helium leak test, and radiographic certification of welds. A typical containment vessel is shown in Fig. 8.3.

In accordance with written procedures, the user quality control (QC) group visually inspects all components on receipt from the vendor in accordance with written procedures for cleanliness and transportation damage. The user QC group also inspects and documents all the "Q" dimensions, plus any additional dimensions at their discretion. Noncompliance parts should be tagged as nonconforming, and established QA procedures should be used to report them.

As standard practice, most sites perform a second full-dimensional inspection of newly fabricated containment vessels upon the vessels' arrival on-site. A separate inspection procedure form is used. Typically, all dimensions are checked, except for weld lengths. All equipment is calibrated prior to each use. Containment vessel nonconformances are handled in the same manner previously described for the drum inspection. Typically, an inspector can examine three containment vessels per day.

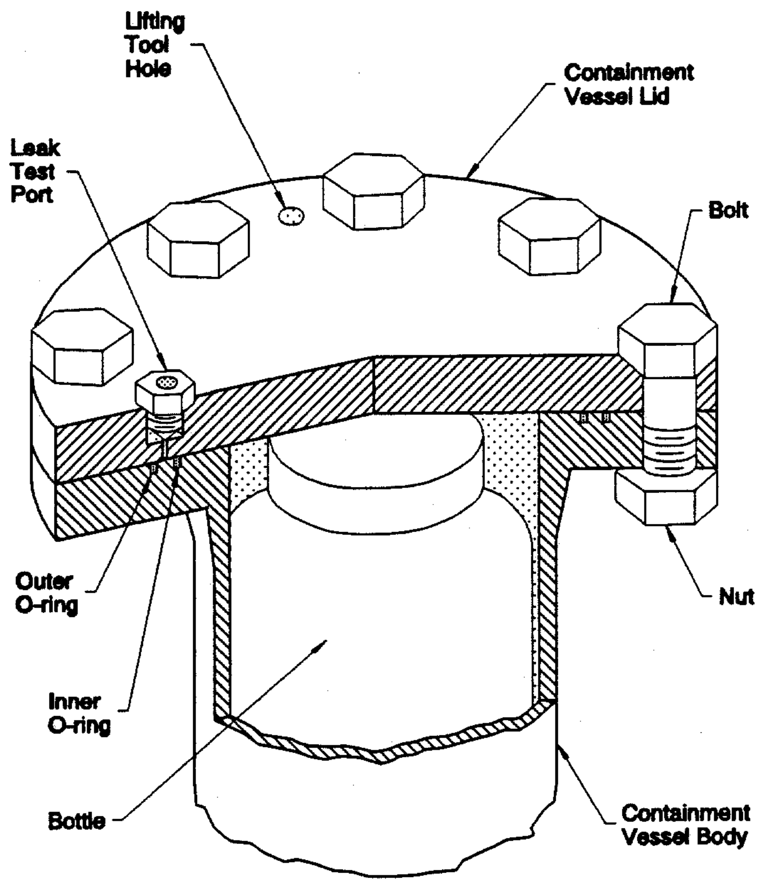

Fig. 8.3. Containment vessel details.

Containment vessel bolts

Bolt vendors provide test reports of mechanical and chemical properties by lots that are traceable to the manufacturer. The user's QC group examines the vendor-supplied data and confirms that the bolts have proper identification markings. Typically, no other visual inspections are required. A lot is rejected if the bolts do not meet the criteria. **Note:** some vendors of bolts are disallowed by DOE directive. Therefore, to avoid counterfeiting, a vendor's credentials should be thoroughly checked.

Gaskets or O-rings

To pass visual inspection, gasket and O-ring surfaces must be *smooth*, nonporous, and free of visible defects. For each lot of O-rings, the vendor provides a certificate of conformance certifying the hardness, tensile, and elongation properties; batch number; and cure date.

Typically, O-rings are individually bagged by size and tagged with batch numbers and cure date. O-rings have quite a long shelf life (5 to 10 years or longer) and therefore do not present a continuous maintenance concern. For example, ethylene propylene O-rings can have shelve lives up to 10 years.

O-rings shall be of one continuous piece with no glue or bond joints. O-rings are received individually packaged in lots from the vendor. Upon receipt of the O-rings, vendor inspection documentation is reviewed and, if this documentation is acceptable, the O-rings are placed into parts storage.

When needed as replacements, O-rings are received from parts storage and visually inspected before use. An O-ring found to be defective at this point will be discarded. O-rings with defects identified by visual inspection are to be tagged "not to be used" and discarded.

8.3.1.2 Common problems identified during visual tests

The typical defects common to all O-rings and gaskets are cuts, gouges, pin holes, and flats due to permanent setting. Metallic O-rings can also have dents and scratches.

8.3.1.3 Dispositioning nonconforming items

Nonconforming items are evaluated and dispositioned by authorized personnel. Rework of nonconforming items may require authorization by the designer and the use of designer approved procedures. Items are dispositioned in accordance with approved site procedures.

The principal elements for controlling nonconformances are: 1) identification of nonconforming item, 2) proper documentation, 3) segregation of the discrepant/nonconforming item, 4) disposition of the nonconformance, 5) notification to other affected organizations, and 6) fulfillment of corrective action requirements.

The identification of nonconforming items should be legible and recognizable and shall not affect function or end use of the item. Where direct identification is impractical, the container, package, or segregated storage area is accompanied by documentation that identifies the nonconforming condition.

Dispositioning decisions such as reject, repair, rework, or "use-as-is" are documented. Items that have been repaired/reworked must meet the original acceptance criteria.

Many DOE facilities control nonconforming packages by segregating them into designated holding areas. These areas are clearly identified by appropriate signs and placards and are roped off.

The process of dispositioning nonconforming items begins by issuance of a report that proposes corrective actions to be taken. This corrective action report includes: 1) identification of the deficiency, 2) the cause, 3) corrective action to prevent recurrence, 4) follow-up to verify implementation and effectiveness of the corrective action, and 5) communication of the deficiency and corrective action to QA personnel and other organizations that could be affected by a similar situation.

8.3.2 Structural and Pressure Tests

Historically, structural and pressure tests have been used to check the structural integrity of a variety of packaging designs. The purpose of these tests is to ensure the packaging meets specified design criteria.

8.3.2.1 Hydrostatic test for fabrication

Internal pressure

This test verifies the structural integrity of the containment vessel (materials and welds) and ensures that the vessel conforms with the design requirements. Pneumatic or hydrostatic pressure tests of containment vessels use air or water at an internal pressure as specified by the package design. The test pressure is commonly based on the design pressure times a "factor of safety" or the *maximum possible* calculated pressure. In many cases, the vendor performs these tests. As a result, the vendor is required to provide reports on the pressure tests for all containment vessels fabricated. The user QC group will examine the vendor-supplied data from these tests and observe the test when possible.

It should be noted that an internal pressure will verify welds of stationary pressure vessels. However, it is not completely adequate for welds subject to dynamic loading or a combination of both. Therefore, the design should allow for the containment vessel welds to be radiographed.

External pressure

This test, which is similar to the internal pressure test, is generally designed to satisfy the HAC 50-ft water immersion requirement. This test also proves that no inleakage of water into the containment vessel will occur.

8.3.2.2 First-use pressure test

Pressure test requirement

10 CFR 71.85(b)l requires an internal pressure test that uses a pressure at least 50% higher than the MNOP. This test shall be performed when the MNOP exceeds 5 psig.

Reusable vessels

If structural and thermal analyses/tests determine that the MNOP in the containment vessels exceeds the 5-psig limit, the vessel shall be tested to a pressure 50% above the MNOP.

Welded vessels

Since welded containment vessels are used only once, special consideration must be given during the design process as to how the requirements of the 50% overpressure test will be met. One solution is to develop a sampling program that tests a sample vessel after a statistically defined interval. This test interval depends upon how frequently containment vessels will be fabricated and how many vessels will be fabricated and shipped during a year. These qualification tests are also performed on a sampling of test specimens prior to the first production run to qualify the fabrication process. Furthermore, to establish a level of confidence, each welder is tested and qualified to perform the welding process.

8.3.3 Leak Tests

Leak tests performed for acceptance ensure that a package meets the containment requirements specified by the package design. In this section, the leak test options available and some of the advantages and disadvantages of each, method are summarized. Some of these methods provide measurements of integrated (total) leakage and others are go/no-go tests that locate discrete leaks. Details of each method and the analytical method for determining the leak rate can be found in ANSI N14.5.[7]

The leak-test method is selected on the basis of the containment system design and the sensitivity required. The sensitivities associated with common leak-test methods are shown in Table 8.2.

Table 8.2. Leak test sensitivities

Test method	Nominal test sensitivity (std cm^3/s)
Gas pressure drop	10^{-1}
Hot water bubble	10^{-2}
Gas bubble	10^{-3}
Soap bubble	10^{-3}
Gas bubble, vacuum, and glycol	10^{-3}
Gas pressure rise	10^{-4}
Halogen detector	10^{-3} - 10^{-6}
Helium mass spectrometer spray or sniffer	10^{-3} - 10^{-6}
Helium back pressurizing	10^{-3} - 5×10^{-8}
Helium mass spectrometer envelope	10^{-3} - 10^{-8}
Tracer gas fill helium or ^{85}Kr	10^{-3} - 10^{-8}

Gas pressure drop

This procedure applies to test items with pressure tap connections, such as gas cylinders. The leakage rate is determined by pressurizing the test specimen to the specified test pressure and measuring the change of pressure and temperature within the test volume during a specified time period.

Hot water bubble

This test applies to small, thermally responsive test items usually sealed without pressure tap connections. The test relies on an internal pressure increase, caused by heat transferred from the hot water, to form bubble streams that will reveal the location of individual leaks.

Gas bubble

This procedure applies to test vessels with pressure tap connections. The formation of gas bubble streams in a liquid bath reveals the location of individual leaks. Various liquids, such as water, alcohol, mineral oil, or silicone oil can be used in conjunction with various tracer gases to vary the test sensitivity.

Soap bubble

A common method in pressure vessel testing is the gas and bubble formation test. Leaks in a vessel are detected by the application of a solution in which bubbles will form when gas passes through the solution at the leak area.

Gas pressure rise

This procedure, which is similar to the gas pressure drop test, applies to test items with pressure tap connections. The gas pressure rise procedure, although less affected by temperature changes than the pressure drop method, may require that all or part of the leakage flow be in the direction opposite that encountered in normal operation. The total leakage rate may be derived from the rate of pressure rise, after correction for temperature change.

Gas bubble, vacuum, and glycol

This procedure is a variation of the gas bubble test and usually applies to test items without pressure tap connections. The formation of gas bubble streams in an ethylene glycol bath reveals the location of individual leaks.

Halogen detector

This procedure applies to test items with or without pressure tap connections and can be used to measure total leakage rates or to locate individual leaks. Accumulation and shroud techniques can be used to increase accuracy and sensitivity and to measure total leakage. Halogen vapor is detected by the rate of ionization either on a heated platinum anode or in an electron capture cell, or by a change in thermal conductivity.

Mass spectrometer, spray, or sniffer

This procedure applies to test items with pressure tap connections. A mass spectrometer leak detector (MSLD) measures a tracer medium, usually helium gas. If leak is present, the leak detector detects the helium gas and sends an electrical signal.

For the mass spectrometer spray test, a small quantity of tracer gas is sprayed onto the test item. The MSLD is then used to check the response time for each portion of the test specimen. A change in the response time indicates a leak.

In the mass spectrometer sniffer test, the tracer gas passes through a leak from the pressurized side to the nonpressurized side. The MSLD is then used to detect the leak. The test can be made under a vacuum, pressure test, or a combination of both.

Helium back pressurizing

This procedure applies to test items without pressure taps and sealed sources that cannot be filled with helium during final closure. The items must be able to withstand the selected external pressure without damage. An MSLD measures leakage by detecting helium.

Helium mass spectrometer envelope

This procedure applies to test items with pressure taps. For this test, the test item is placed in an envelope, such as a well-sealed metal box. The test item is purged and pressurized with helium at slightly greater than atmospheric pressure. The envelope is then evacuated with an MSLD. Conversely, a second method is to evacuate the item and place the item into an envelope that is slightly greater than atmospheric pressure.

Tracer gas fill

This procedure applies to small test items without pressure tap connections that can be filled with a suitable tracer gas, usually helium or ^{85}Kr. A helium MSLD is used to measure the leak, or a counter is used to measure the gamma activity from ^{85}Kr.

8.3.4 Component Tests

Component tests prove that individual packaging subsystems meet their design performance goals. Thorough testing is an essential part of the QA program.

8.3.4.1 Valves, rupture disk

Acceptance tests of valves and rupture disks are required to show compliance with the package design requirements and to ensure that the system will conform to regulatory requirements. Guidelines for testing of containment components are provided in this section. This section is intended as an introduction and should be considered only as a supplement to existing standard practices and regulations.

Individual acceptance tests for valves can be useful for screening borderline components before their inclusion in prototype or production hardware. These tests are simple and relatively inexpensive to perform. In general, borderline components should be tested under the most severe service conditions for which the package design assumes their acceptable performance. If adequate QA is evident, screening may be unnecessary or at least necessary only intermittently. The designer is responsible for determining the necessity of the valve acceptance tests.

Containment system verification requires more complicated test systems. Type B package containment systems should be leak- or release-tested per ANSI N14.5.[7] The method of testing is determined by the degree of accuracy required and the package design, as noted in the standard. This standard also provides details for calculating the maximum permissible leak rates. Test models should be prepared as for shipment, subjected to NCT and hypothetical accident conditions (HACs) (including regulatory fire conditions), and tested to show that they have leakages less than or equal to the maximum permissible rates. The radioactive contents may be simulated during the test, and only one specimen of a particular design need be tested to verify the integrity of a containment system. Note also that the integrity of a containment system can be verified by comparison, if a previously verified comparable design exists. Limited testing may be used to supplement the comparison.

Containment system fabrication tests are required before the first use of each reusable containment system. Where possible, all joints and seals on the containment system should be tested in the fully assembled state, but radioactive contents may be simulated. In some cases, joints and seals may have to be tested at the subassembly or component level. Single-trip containment systems shall be tested to the same requirements as reusable systems, except that the sample size may be less than 100% and the testing shall have been completed in the preceding 12 mo.

Periodic verification tests of containment system are required for reusable Type B packages. A shakedown period is specified (normally the first three uses). Before each use during this shakedown period, verification tests should be performed as described for containment system fabrication test (see Chap. 4). In addition, before use for shipment, these should have been tested according to the containment fabrication test within the preceding 12 mo. Periodic verification of the containment system need not include the testing of inaccessible joints and seams but should include all components such as closures, valves, pipe fittings, and burst disks.

Containment system assembly verification tests are required prior to each shipment of Type B packages. These tests are designed to verify proper assembly and to ensure that the containment function has been established. The required test depends on the NCT for the package.

Rupture disks provide additional protection against leakage of contents when used in conjunction with a valve. When used without a valve, rupture disks relieve overpressure conditions. The rupture disk burst pressure is certified by the manufacturer and should be marked on the disk. The user should verify that the manufacturer's burst pressure falls within the expected design range. For example, the ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NB,[8] suggests using one of three methods, described in the following lists, for acceptance testing of rupture disks.

1. At least two sample rupture disks from each lot of rupture disks shall be burst at the specified disk operating temperature. A lot is considered to be a set of rupture disks manufactured of the same material at one time and of the same size, thickness, type, heat, and manufacturing process, including heat treatment. If the specified disk temperature is not room temperature, at least one additional disk shall be tested at room temperature. The rating at the specified disk temperature shall be the average of the tests conducted at that temperature.

2. At least four sample rupture disks, but not less than *5%,* from each lot of rupture disks shall be burst at four different temperatures. The test should be distributed over the applicable temperature range for which the disk would be expected to operate. These data shall be used to

establish a smooth curve of burst pressure versus temperature for the lot of disks. No point shall fall more than 3% from this curve. The rating at the specified disk temperature shall be interpolated from this curve.

3. For various types of disks and test procedures where it can be shown that the data will plot a smooth curve and that no point lies outside of 3% of this data, a series of four or more burst tests can be made on one lot of disks at the specified disk temperature. The parameters from these tests can then be used to manufacture the disk.

8.3.4.2 Gaskets

Gaskets should be tested under conditions simulating the most severe service conditions under which the gaskets are to perform. If the actual system that the gasket will be part of is not used in the test, the simulation must ensure adequate representation of those conditions that would prevail if the actual system were used. Many gasket physical characteristics are important in assessing seal performance. Hardness, tensile strength, elongation, and modulus are a few of these characteristics. The specific application determines which of these characteristics are most crucial, and the designer is responsible for evaluating which parameters of those characteristics, if any, should be subjected to acceptance testing.

The containment system tests described in the preceding section give guidance for the acceptability of containment system leak tests. Since the gasket is an integral component of the containment system, these tests provide an assessment of the adequacy of the overall gasketed joint.

All components of the containment system (valves, rupture disks, and gaskets) should be procured under a quality assurance program adequate to ensure that acceptance testing of a given component is equivalent to acceptance testing of all components supplied and identified by that manufacturer and identified as being a particular model.

8.3.5 Shielding

The user must be able to confirm that the shielding is present and functioning; that the external radiation levels on and around the package are below regulatory limits; and that the level of nonfixed radioactive contamination on the accessible surfaces of the package is as low as reasonably achievable (ALARA).

Shielding integrity must be assured prior to each shipment of a package. Physical presence of the shielding can be confirmed by visual inspection. External radiation levels are usually determined by direct measurement with a known source simulating the contents.

Direct measurement using a known radiation source may not always be possible. Some packages may have to be loaded with the actual contents. In the case of one isotope container, no adequate neutron sources for shielding integrity tests were available at the time of fabrication. Therefore, integrity was assured by control of the mixing and pouring of the package's concrete shield. Limonite concrete was used because of its excellent neutron absorbing abilities. In accordance with the requirements of 10 CFR 71,[1] direct measurements on the external surfaces of the package and at 1 m were performed after loading, but prior to shipment, to verify the integrity of the shielding. Nonfixed contamination of the external surface of the package is determined by the "swipe" method. An area of the external surface of the package is determined by the "swipe" method. An area of the external surface is swiped with a cloth. A portable radiation detector is then used to determine the amount of contaminants on the cloth.

The radiation level of contaminants found on the cloth is divided by the area swiped to determine the level of radioactive contamination per unit area.

Storage and handling activities must not degrade the integrity of the shielding; in addition, any special storage or handling requirements for the shielding must be considered, recognized, and identified by the designer.

8.3.6 Subcriticality Assurance

A package used for the shipment of fissile material must be designed and constructed and its contents so limited that the contents would remain subcritical even if maximum reactivity of the fissile material is obtained. The package must also be designed and constructed so that under NCT the contents remain subcritical, the geometrical form of the package is not substantially altered, no inleakage of hydrogenous liquid can occur, and no substantial reduction in the effectiveness of the package occurs. The package must also remain subcritical under HAC where the fissile material is in the most reactive credible configuration with optimum interspersed moderation.

Packages used for shipments of fissile materials are divided into three classes. A package for a Fissile Class I shipment must be designed and constructed and its materials so limited that any number of undamaged packages would remain subcritical in any arrangement with optimum moderation. When subjected to HAC, 250 packages would remain subcritical when stacked in any arrangement with optimum interspersed moderation.

A package for a Fissile Class II shipment must be designed and constructed and its materials so limited that five times the allowable number of packages could be stacked together in any arrangement with optimum interspersed moderation and still remain subcritical. If the packages have been subjected to HAC, then twice the allowable number of packages must remain subcritical when stacked together with optimum interspersed moderation.

A package for a Fissile Class III shipment must be designed and constructed and its materials so limited that twice the number of undamaged packages would remain subcritical if stacked together in any configuration with optimum interspersed moderation. The allowable number of packages in a Fissile Class III shipment must remain subcritical after being subjected to HAC and with optimum interspersed moderation.

8.3.6.1 Fabrication records

The package manufacturer must provide detailed fabrication records to the purchasing contractor or owner. These records contain properties of the materials used to construct the package. From these material properties, the purchaser will be able to verify the strength and integrity of the package as well as if the proper materials (i.e., neutron-absorbing materials) were used in the fabrication process. The purchaser will also be able to determine if the interior geometrical configuration is constructed to specifications and is geometrically favorable for subcriticality.

8.3.6.2 Neutron absorbers

The presence of a neutron absorber or neutron absorbing material in the package will be revealed by the fabrication records. An experiment should then be performed on the package to ensure that the neutron-absorbing material is still functional. This may be accomplished by loading the package with a measured neutron emitting source and taking direct measurements. If no neutrons are detected, then the absorber is still functional and the package may be used for shipment.

8.3.6.3 Acceptance criteria

The responsibility of ensuring subcriticality of the shipment lies with the owner/user. If applicable, the owner/user must check the fabrication records for neutron-absorbing materials and ensure that these materials are functioning. The package is acceptable if the absorbers are in place and functioning. The owner/user must also ensure that the configuration of the package is geometrically favorable for nuclear subcriticality. Visual inspection of the package will verify the geometrical shape of the package, and the fabrication records should be used to determine the strength and integrity of the package to ensure that no substantial change in geometrical configuration will occur during HAC.

8.3.7 Thermal Tests

Containers designed to transport radioactive material with decay heat should be tested to demonstrate their heat load capabilities unless these capabilities are demonstrated.

8.3.7.1 Acceptance criteria

The acceptance criteria should be determined with the aid of the package designers to ensure that the manufactured packaging is the same as the design analyzed and/or tested in the SARP and meets all regulatory requirements. For instance, if a package design uses an insulating material, and the thermal analysis in the SARP used the thermal properties of this insulating material, then acceptance criteria should be specified to ensure that the insulating material in the manufactured package has the same properties as those used in the analysis.

Packaging components essential to the thermal performance of the package should be demonstrated to comply with the design unless compliance can be otherwise demonstrated.

8.3.7.2 Typical demonstrations of acceptability

Packaging components. A typical packaging component essential to the thermal performance of a package is an insulating material (such as cane fiberboard). Insulating materials can vary by manufacturer and by lots produced at different times by one manufacturer. Therefore, demonstrating that the material is consistent with that specified for the package design is essential.

Frequently, manufacturer quality assurance data are provided with insulating materials. This information can be used to verify that the insulating material meets the design requirements. However, when manufacturer quality assurance data are not provided, measurements should be made to verify the acceptability of the material (e.g., density measurements to ensure that the material is within acceptable density range).

Whole package. The package as a whole should be evaluated to determine the acceptability of its thermal characteristics. The acceptance test should be designed to ensure that the actual package is consistent with the package design. For example, a new package can be loaded with a known heat source (e.g., electrical heater) equivalent to the heat generated by the decay of the radioactive material being shipped. Temperature gradients across major materials and at material interfaces can then be measured. These temperature measurements can be made with the use of thermocouples or temperature indicator labels. The acceptance criteria should account for the sensitivity of the method for measuring temperature.

The following example is provided to demonstrate an actual thermal acceptance test used to evaluate new drum-type packages. The test was developed to ensure that the heat load capabilities of the package are acceptable for NCT. A representative sample package is tested in the following manner:

1. Assemble a package with the maximum permissible amount of heat-generating material.

2. During assembly, attach thermocouples to the outside top and side of the containment vessel and to the outside top and side of the drum surfaces.

3. Place the package in a normal condition environment of 100^0F until steady-state temperatures are reached. Record temperatures.

4. The temperatures should not exceed 250°F on the containment vessel and 136°F on the drum surface. If the temperatures are exceeded, notify the design agency for the packaging.

8.4 MAINTENANCE

Each package owner is responsible for developing a program to maintain the packaging consistent with the basic maintenance requirements for safety stated in the SARP. A successful maintenance program ensures that the packaging continues to meet all design and safety requirements and has not deteriorated with time and usage. A typical maintenance program includes 1) storage, 2) refurbishment (repair and replacement), and 3) inspection.

Development of a successful maintenance program also depends upon the complexity of the packaging. A simple design generally means a package is easy to use and maintain. Maintenance will be necessary when an observation reveals an apparent defect or when an anomaly occurs during annual inspection and testing.

Most packagings have few storage requirements—a covered area, perhaps; limits on stacking; or special handling equipment. Some packaging components do require special protective coverings, temperature controls, or humidity controls (e.g., exposed sealing surfaces and insulation). These requirements should be defined in the packaging-specific QA plan and maintenance program activities should ensure that the identified requirements are met.

Damage that results from wear and tear must be repaired in accordance with approved procedures. All such repairs must be documented in accordance with approved QA procedures. Replacement of packaging components such as fittings, O-rings, gaskets, and bolts is considered normal maintenance.

When nonconformances that go beyond simple acceptable fixes are found, the packagings involved should be labeled and segregated until final disposition by the cognizant party or parties. Disposition may be decided by an individual, but at most locations such decisions are made by a team comprising representatives of the Process Engineering, Material Control, Mechanical Engineering, Quality Engineering, and Procurement Quality Engineering groups.

All packages are subjected to periodic tests and inspection. Refurbishment inspections may be required prior to each use of the package, and annual leak tests may also be required. Typically, a refurbishment procedure is prepared for each individual type of packaging and a refurbishment inspection form is filled out for each packaging that undergoes refurbishment.

During refurbishment, the packaging is opened and the containment vessel is removed. The drum is then cleaned and all stickers are removed. The identification tag and certificate number are checked; if the drum or containment vessel is going to be used for different authorized contents, then the tag(s) and certificate number on the container are changed during refurbishment.

Packages stored for several years and then used for shipping at the end of the storage period must pass a postload leak test immediately prior to shipment.

Types of periodic tests inspections and maintenance operations typically performed on packages are described in the following sections. Nondestructive examination personnel shall be qualified and certified for the examination method used in accordance with the American Society for Nondestructive Testing (ASNT) Recommended Practice No. SNT-TC-1A (Level II for helium leak testing and for dye-penetrant examination). Personnel performing other activities that directly affect the quality of the packaging shall be qualified to perform such activities on the basis of appropriate training, education, and experience and/or by demonstrated performance (see Table 8.3).

8.4.1 Structural and Pressure Tests

Structural and pressure tests verify the integrity of the packaging when subjected to design loads. These tests are based upon a set of well-defined acceptance criteria and tests that bound the design requirements of the package. Acceptance criteria and test frequency should be based on the quality level requirements of the component(s) being tested.

Table 8.3 Summary of maintenance program activities

STORAGE
- Visual inspection
- Environmental requirements met

REFURBISHMENT/REPAIR/REPLACEMENT
- Visual inspection (outer container, inner containers, valves, gaskets, rupture disks, O-rings, bolts)
- Routine replacement
- Periodic replacement
- Repair-as-needed (per approved procedures)

INSPECTIONS/TESTS
- Refurbishment inspection (visual)
- Hydrostatic pressure test
- Helium leak test

- Postload leak test
- Thermal load test
- Radiation level reading for shielding

The hydrostatic test, which calls for immersion under a head of water of at least 15 m (50 ft) for not less than 8 h, may be required. For test purposes, an external pressure of water of 147 kilopascal (21 psi) gage for not less than 8 h, is considered to meet these conditions. During each reuse inspection in one specific case, special attention is given to the O-ring sealing surfaces serving as a barrier to water leaking in. In the event of damage to the sealing surfaces, the vessel is hydrostatically tested and approved for reuse before being placed back into operation.

In another instance, a containment vessel is pressurized to its maximum allowable internal working pressure at 12-mo intervals or before every fourth usage, whichever occurs first. Because of the geometry involved, it is possible to establish as the acceptance criterion that no visual deformation of the vessel can occur.

In a third instance, each containment vessel is proof tested at 200 psig with helium for a minimum of 4 h before its first use and every 2 years thereafter. Before each shipment, the container is proof tested at 1.5 times the maximum pressure possible during the shipment.

In a final example, a secondary vessel is pressure tested at 425 ± 10 psi at 70 ± 10°F per Section VIII, Division 1, Article UG 99 of the ASME Boiler and Pressure Vessel Code.[9] The test is repeated every 2 years. The criterion for acceptance is no loss of pressure over a period of about 1 h. The test sensitivity is dependent on the test gages; at ± 1 % accuracy for a full scale of 1000 psi, this would be ± 10 psi.

Note that there is a trade-off between pressurization testing and the cumulative stress that the vessel is subjected to as a result of such testing. Nevertheless, when the MNOP of the containment vessel exceeds 5 psig, the containment system must be tested at an internal pressure at least 50% higher than the MNOP. Reusable containers are fitted with pressure connections to enable periodic monitoring.

The testing of welded containment vessels requires several special considerations. The first consideration is how to test such vessels. One method is to fit a sample vessel with pressure fittings to provide a means of pressurizing the test vessel.

A second consideration is how to test the vessel at the operating temperature. Two possible solutions have been proposed. The first is to use an internal heating unit that heats the vessel to the operating temperature during the test. A second, less invasive method is to perform the pressure test at ambient temperature conditions and raise the pressure at which the vessel is tested. Raising the pressure compensates for the difference in material properties at ambient and operating conditions. The amount of pressure applied depends upon the actual operating temperature.

A third consideration is how often to perform this test. Testing each vessel individually is impractical; one solution would be to develop a sampling plan.

The following example illustrates the use of a sampling plan. Two "sample" vessels equipped with pressure fittings (two primary and two secondary containment vessels) prepared initially by each certified welder are tested to qualify the fabrication process. If all test specimens satisfy the test requirements, production of the containment vessels may begin. However, if a test vessel fails to satisfy all requirements, the test series must be repeated, following the required modifications to the fabrication process, until each certified welder successfully produces sequentially two vessels of each type that pass the test. Thereafter, from every 20th package produced by each welder, one primary and one secondary containment vessel shall be subjected to the overpressure test. If a vessel does not satisfy the test requirements, the sequential test described previously shall be repeated.

Another approach to handling welded vessels is to present appropriate material certifications, together with documentation that the wall thickness of the container has been scanned to show that it meets required minimum thickness everywhere. (This can be done ultrasonically, for example.) In conjunction, an analysis of the welds is carried out in accordance with the ASME Code. The case is then made that all of the vessels are acceptable.

8.4.2 Leak Tests

8.4.2.1 Annual test

For many containment vessel systems, a helium leak test is performed to verify the integrity of the containment vessel. After the first several uses, the helium leak check is only performed annually. If the containment vessel fails, it is torn down and the O-rings are checked and replaced if necessary; then the inner container is reassembled and the test is performed again. If the inner container continues to fail or if gross failure is observed, the "Product Engineer" is notified. The container is tagged and stored in an official nonconforming segregation area until disposition is determined.

If the containment vessel passes, it is torn down and the inner components are reassembled and tested for leaks. Then the package is reassembled and moved to refurbishment inspection until approval is received. The assembly inspection forms are review by QA personnel, who issue the approval for the packaging. After approval, the packaging is stored until needed, sent to another user, or loaded with contents.

For packages shipping contents in powdered form, the measured leak rate must be less than 1×10^{-7} std cm^3/s air. To accomplish this test, in one instance, annual leak tests are performed with the aid of a leak test adapter plate. Experience using the adapter plate for the leak test has shown that the leak rate will be well within the leaktight range, although the use of the adapter plate enables testing of two O-ring seals in parallel. This adapter plate is necessary as a means of introducing helium into the containment vessel cavity. Used O-rings are discarded and new ones installed for the annual leak test.

For another case, at 1-year intervals, the containment vessels are leak tested with helium at 150 psig (1.5 times the MNOP of 100 psig). The leak test, performed in accordance with ANSI N14.5, must show that the leak rate is less than 1×10^{-7} std cm^3/s air. The sensitivity of the leak test must be less than 1×10^{-8} std cm^3/s air. If the containment vessel is not used for shipment for a period of 1 year, the leak test must have been performed during the 12 mo preceding the vessel's use for actual shipment. Personnel performing the helium leak test are required to verify helium fill of the pressure vessel by valving off the helium supply during the fill process and checking to see if the pressure drops. A drop in pressure indicates that helium is flowing into the containment vessel. If the containment vessel immediately rises to regulator pressure, the flow passageway is blocked. The blockage must be cleared before a valid leak test can be performed.

As another example, a secondary vessel is leak tested after the third use and then at 1-year intervals. Helium gas at 100 ± 5 psig is introduced into the secondary vessel through the leak-test port in the vessel top. As per the ANSI code, the flange closure is leak tested by using the helium mass spectrometer sniffer with sensitivity of 1×10^{-8} std cm^3/s air. Acceptable leakage is to be less than 1×10^{-7} std cm^3/s air.

At one site, two methods are used to leak test the containment vessel. One is the pressure test, in which the containment vessel is filled with helium and then sniffed with a helium mass spectrometer. The other method is the vacuum test in which helium is sprayed on the outside. Some leaks are one-directional. Accordingly, performing both tests wherever possible is desirable. The spray test seems to work better. Helium sniffing is subject to the "cleanliness" of the surrounding atmosphere — that is, the freedom from helium, which can accumulate. Also, the pressure test is less sensitive; under ideal conditions, according to a calibrated source, this test is good to 1×10^{-6} std cm^3/s air. More generally, the test is good to 1×10^{-4} std cm^3/s air or 1×10^{-5} std cm^3/s air. The spray test is good to 1×10^{-9} std cm^3/s air.

A further word is in order about leak testing seals. The direction in which the seal is intended to block leakage should be taken into account in deciding how to set up the leak test.

8.4.2.2 Tests performed prior to shipment

After the contents are placed into the containment vessel and the vessel lid is secured, a postload leak test (often gas pressure rise) is carried out in accordance with ANSI N14.5. This test measures the pressure rise in the annulus between the O-rings. The measured leak rate must be less than 1×10^{-3} std cm^3/s for test acceptance. Here and elsewhere, the sensitivity should be stated. If leakage is determined to exceed the acceptable limit, the condition must be corrected prior to shipment. This correction may involve removal of the lid, examination and/or replacement of the O-rings, and examination of the seal contact surfaces. If the leakage criterion cannot be satisfied, the package must be set aside and not used until it is brought into compliance. Note that if any components such as O-rings have been replaced and/or similar changes have been made since the last annual leak test, then the acceptance criterion is a leak rate not exceeding 1×10^{-7} std cm^3/s air.

Consider this example: After the radioactive material is placed inside the containment vessel, but before shipment, the closure of the containment vessel shall be proven to be assembled correctly by use of a checklist and leakage test in accordance with approved procedures. The leak test shall indicate leak to less than 1×10^{-3} std cm^3/s air with a test sensitivity of 5×10^{-4} std cm^3/s air when the leak test port is pressurized to at least 150 psig (1.5 times the maximum normal operating pressure of 100 psig). A pressure drop test method or alternate test method that meets these acceptance criteria shall be used in accordance with ANSI N14.5.

In yet another instance, the secondary vessel shall be leak tested by applying 100 ± 5 psig nitrogen gas through the leak test port into the cavity of the secondary containment vessel and detecting leakage with soap solution around the closure. The test shall be performed after loading and prior to each shipment. The sensitivity for this test is 1×10^{-4} std cm^3/s air. An acceptable leak rate is less than 1×10^{-3} std cm^3/s air.

With welded containment vessels, new vessels are used for each shipment. Each vessel is leak tested with a mass spectrometer. The leak rate must be less than the leaktight requirements of ANSI N14.5 (1×10^{-7} std cm^3/s air).

8.4.3 Subsystem Maintenance

Routine maintenance on reusable packaging may be performed or obtained as deemed necessary by any of the inspectors or users and is limited to cleaning, rust removal, painting, light metal working to restore the original contours (i.e., repairing dents, screw threads, etc.) and replacement of damaged, worn, or malfunctioning components.

Packagings should be stored inside. Empty containers should be stored with gaskets in place to protect sealing surfaces; for this purpose, used gaskets are acceptable.

8.4.3.1 Drum

Before every use, the drum is visually inspected for dents, tears, defective welds, or other damage. Any drum with dents deeper than 1/4 in. must be reshaped to an acceptable condition. Holes may sometimes be repaired if special procedures are developed and approved. Drums, lids, or closure rings and bolts that are out of conformance and cannot be repaired are discarded and replaced. The insulation is visually inspected for cracking, delamination, deterioration, or other signs of wear. Defective insulation assemblies may be repaired or replaced. The drum identification plate is inspected to ensure that the information remains legible. If the information on the identification plate becomes damaged, repairs are made by stamping or by replacing the plate. If vent holes are present that must be plugged, the plugs are inspected for signs of damage. Damaged plugs are removed and replaced. The packaging may be used without the plugs if the vent holes are, as an alternative, covered on the outside of the drum with vinyl weatherproof tape. Grit-blasted surfaces may be retreated as necessary.

8.4.3.2 Containment vessel

Containment vessel sealing surfaces are to be visually inspected for nicks and scratches. The sealing surfaces may be machined to acceptable conditions. Approved procedures must be used to perform the rework. After surface rework, the containment vessel must be leak tested as it was during acceptance testing. To minimize damage to the vessel, the sealing surfaces may need to be temporarily protected with plastic. Flange bolts and screw threads are to be visually inspected. Defective items are to be replaced. Replacement bolts must be obtained from controlled stock and must have the proper material traceability and markings.

8.4.4 Valves, Gaskets, and Rupture Disks

Valves are tested before each usage and replaced as necessary. A new copper gasket is used for each shipment. Frequently, packages are purposely used without a drum gasket. The resulting strong closure offers better impact protection. (the resilience of the gasket can result in damage to the retaining ring in the 30-ft drop.) Also, in a fire the gasket would burn and leave an open path for further combustion.

The inner and outer containment vessel O-rings are visually inspected for surface defects and discontinuities, such as rough or porous conditions. Each time the package is used, a leak test to better than 1×10^{-3} std cm^3/s air is performed to verify the sealing ability of the O-rings. O-rings are replaced when they no longer satisfy the visual or leak tests. Often the package's maintenance procedure requires replacement of O-rings at the time of the annual leak test. If O-rings are replaced, the seal is treated as new and is tested to a leak rate not exceeding 1×10^{-7} std cm^3/s air.

O-rings shall be individually wrapped to prevent damage in shipment and labeled to ensure traceability. Certification of materials and size shall be furnished by the vendor. All O-rings shall be examined for defects before use. O-rings shall be controlled spare parts. O-rings shall be retained for use until an established shelf life limit is reached.

8.4.5 Shielding

As applicable, gamma and/or neutron scans are performed after each loading, but before shipment. The scans verify that the shielding is still in place and is still functional. The maximum radiation level of the package is measured at the exposed external surface and 1 m from the external surface. The radiation levels are not to exceed 200 mrem/h at the surface or 10 mrem/h at 1 m.

Although a package may have no components that are specifically intended for shielding, the materials of construction may provide some shielding of the contents as well as providing stand-off distance. Accordingly, these materials are visually inspected prior to reuse and during loading operations. Defective items are replaced or repaired to their original condition.

8.4.6 Thermal

8.4.6.1 Schedule development

For packages that transport radioactive material with decay heat, a maintenance schedule should be developed to ensure that heat is being rejected from the package at the design rate. Therefore, the developer of the maintenance schedule should be aware of those packaging components in the design whose heat transfer capabilities degrade with time and use. The frequencies of inspections and tests should be sufficient to ensure that all packaging components that degrade with time and use are functioning properly for each shipment.

8.4.6.2 Methods to detect degradation of packaging components

Methods used to detect degradation of packaging components are visual inspection, measurements, and testing.

As stated in 10 CFR 71.87(k), prior to each shipment of licensed material the licensee shall ensure that the temperature of the accessible surface of the package will not exceed the limits specified in 10 CFR 71(g) at any time during transportation. This test can be accomplished by placing a heat source (e.g., radioisotopic decay or an electrical heater) equivalent to the heat generated by the decay of the actual contents in the package for testing. As applicable, the thermal gradients are recorded for every shipment and correlated with the decay heat. This process checks that the heat generated by the decay of the radioactive material is being rejected at the design rate.

All packaging components that are important to the thermal performance of the package should be inspected and measured. All maintenance repairs should be made according to an approved procedure, or degraded parts should be replaced.

8.4.6.3 Examples of packaging degradation tests

At one site, a random sample of a particular type of package is selected at 12-mo intervals. The containment vessel is instrumented by applying Wahl "Temp-plate" labels or the equivalent to the outer surface. The labels selected indicate temperatures in the range of 200°F to 280°F in approximately 20°F increments. The package is then used for shipment and the “Temp-plate” label surveyed upon disassembly. If the temperature criterion (in this case, no temperature greater than 260°F in an ambient environment of 75°F) is exceeded, the information is reported to the shipping container design group for correction of the deficiency.

In the case of another package, each cask is loaded with the maximum quantity of PuO_2 desired to be shipped, and the exterior surface temperature of the cask is measured and recorded. The exterior surface temperature of the cask and containment vessels is verified to remain within the range of values established by analysis and/or testing as safe limits. This evaluation is made on every new cask and all packages in use at 2-year intervals.

8.5 RECERTIFICATION AND DECERTIFICATION

8.5.1 Packaging Useful Life

A packaging that reaches the end of its useful physical life due to damage, defects, or nonrepairable deterioration needs to be disposed of in accordance with the response to nonconforming items specified in the SARP. A design and its packagings that are no longer needed must be decertified. Decertified packagings may be used for on-site storage or transportation as long as they meet the requirements for the type of usage desired.

A packaging design that is required for continued use by either the original owner or user or others must be recertified prior to expiration of the certificate of authority. If the certificate expires before the recertification is complete, then the packaging must be treated as decertified until the certification is renewed. In some cases, an extension may be granted by the certifying authority pending pursuance of approval for recertification. In all cases, packagings must meet all performance requirements and pass all required acceptance tests before continued use. A flow chart depicting the recertification and decertification options is shown in Fig. 8.4.

If a packaging is no longer needed by the original owner or user, the owner must notify the certifying authority. If the packaging is needed, the certifying authority can transfer ownership to another user. The new owner then becomes responsible for recertification of the packaging.

8.5.2 Recertification

Packaging can be used only if the owner or user is in possession of a valid certificate of compliance. The period of time the certificate is good for and any other limiting conditions are stated on the certificate. Any other use of the package is prohibited. Before the certificate expires, the owner should prepare and submit the application (SARP) for renewal. Packagings must meet all current requirements for certification, even if the packagings were designed, manufactured, or used previously under different requirements.

8.5.3 Decertification

When a valid certification of compliance no longer exists for a packaging, the packaging must be decertified. The certifying authority issues a decertification notice to the owner who, in turn, notifies all users that the packaging has been decertified and may no longer be used for off-site shipments. The owner and all users must update their offsite transportation certificate (OTC) manuals, label the packaging as decertified, and segregate it until final disposition has been determined. Records for decertified packagings must be maintained for at least 3 years after destruction of the packagings. Upon decertification of a package, the identification label is eradicated or removed.

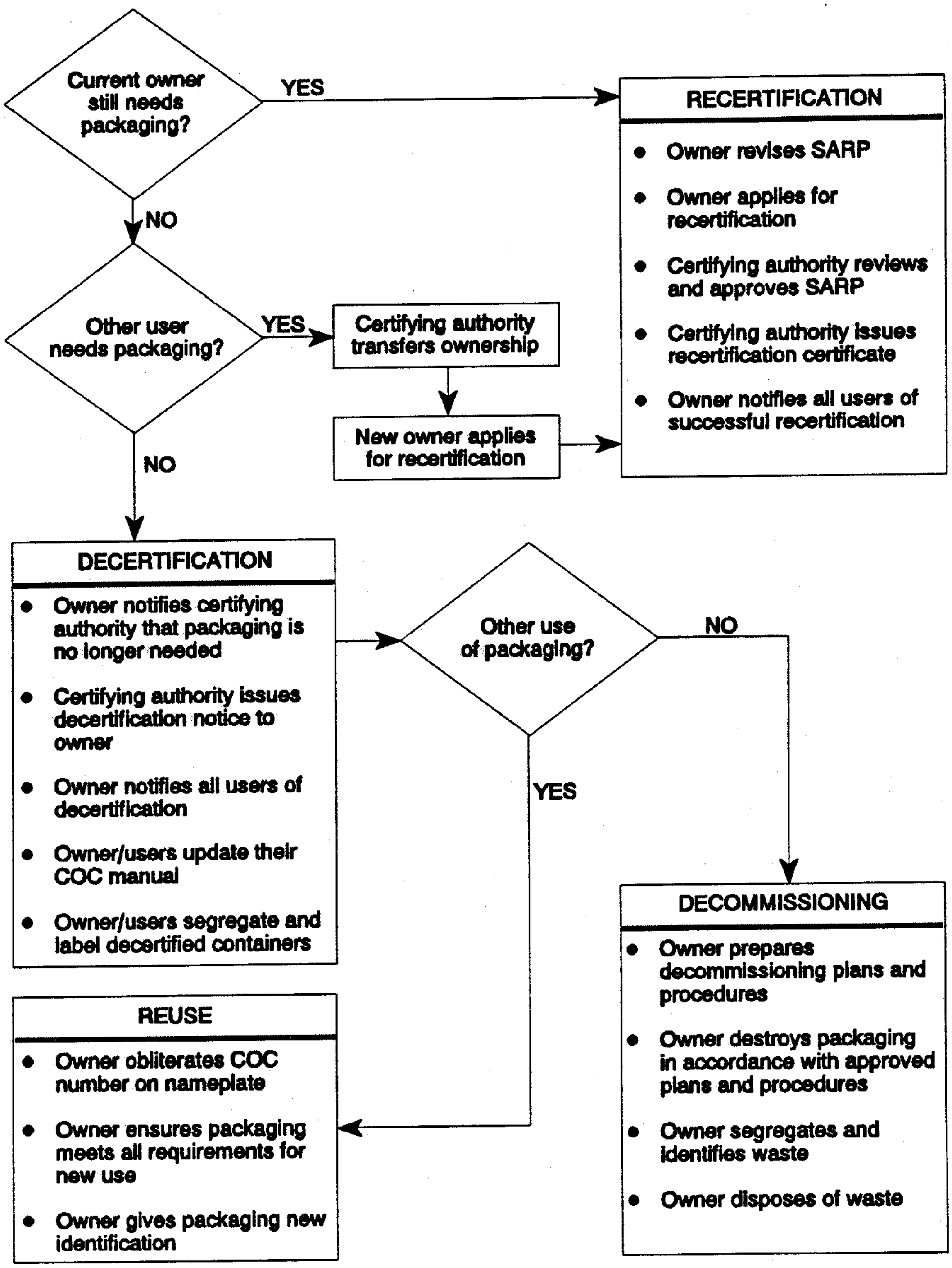

Figure 8.4. Recertification/decertification process flow.

8.5.4 Reuse

If packaging is needed for on-site storage or transportation and the decertified packaging is suitable for such use, the owner/user must obliterate the OTC number on the nameplate, ensure that the packaging meets all requirements for its new use, and provide new identification for the packaging. Note, that the packaging must be traceable to its origins. Therefore, all original documentation must be maintained for the life of the packaging.

8.5.5 Decommissioning

Decommissioning is the act of removing a packaging from service completely. Decommissioned packages are usually destroyed. The owner of the decertified and no-longer-needed packaging should prepare decommissioning plans and procedures. The packaging can then be destroyed in accordance with those plans and procedures. The destroyed packaging (whether clean or hazardous) should be disposed of as indicated by the owner's site-specific waste management plans.

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8.6 REFERENCES

1. U.S. Nuclear Regulatory Commission, *Packaging and Transportation of Radioactive Material*, Code of Federal Regulations, Title 10, Part 71, Washington, D.C.

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3. U.S. Department of Energy, *Hazardous Material Packaging for Transport - Administrative Procedures,* DOE Order 1540.2, Washington, D.C.

4. U.S. Department of Energy, *Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes,* DOE Order 5480.3, Washington, D.C.

5. U.S. Department of Energy, *Quality Assurance,* DOE Order 5700.6C, Washington, D.C., August 21, 1991.

6. U.S. Nuclear Regulatory Commission, *Standard Format and Content of Part 71 Applications for Approval of Packaging for Radioactive Material,* Regulatory Guide 7.9, Rev. 2, Office of Nuclear Regulatory Research, Washington, D.C.

7. American National Standards Institute, *American National Standard for Radioactive Materials-Leakage Tests on Packages for Shipment,* N14.5-1987, New York, 1987.

8. American Society of Mechanical Engineers, *ASME Boiler and Pressure Vessel Code,* Section III, Division 1, Subsection NB, New York, 1992.

9. American Society of Mechanical Engineers, *ASME Boiler and Pressure Vessel Code,* Section VIII, Division 1, New York, 1989.